Forest Health and Adaptation in Alberta

Annual Report 2014

Alberta Government

2014 Annual Report
Forest Health and Adaptation Program
Environment and Sustainable Resource Development

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Cover photo: Spruce beetle infested white spruce stand.

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Duncan MacDonnell (Public Affairs Officer) reviewed the final draft of this report. Gwen Edge (Graphic Designer, ESRD Communications) formatted, designed and published the report.

The Forest Health and Adaptation staff gratefully acknowledges support provided by the multiple individuals, agencies, municipalities and forest companies that helped with the successful completion of the 2014 Forest Health and Adaptation Program.

Executive Summary

This is the 2014 annual report for the Forest Health and Adaptation program of Environment and Sustainable Resource Development. This report contains details of detection, monitoring, assessment, and management of forest health damaging agents that affected the forested Crown land in the Green Area of Alberta, and related programs carried out in 2014. It also summarizes details on seed research findings, seed collections, plant propagation, and genetic trial measurements.

In 2014, the mountain pine beetle, eastern spruce budworm, aspen defoliators, forest pathogens and damage caused by abiotic agents affected trees in the Green Area. Invasive plant species continue to increase, threatening biodiversity. Other forest health and adaptation-related programs are described.

The mountain pine beetle (*Dendroctonus ponderosae*) continued to be the main forest health damaging agent in Alberta in 2014. In the 2013 'beetle-year' reported here, long-distance dispersal monitoring did not indicate an influx of beetles into the province from British Columbia. Heli-GPS surveyors detected 208,459 beetle-infested pines in 2013. In most areas the number of infested trees detected increased from previous years. The green:red survey results indicated decreasing beetle populations along the eastern and southern extent of the outbreak area, with stable to increasing populations south of Grande Prairie and toward Whitecourt. Ground surveyors detected 17,492 high risk green attack pines for treatment. During treatments, all of beetle-infested high risk green attack trees were removed. The r-value surveys captured in the spring of 2014 indicated a decrease in beetle overwinter success from 2013. The Mountain Pine Beetle Reforestation Seed Inventory Enhancement Program collected 4,866 kg of lodgepole pine seed in 2013/14 from 23 seed zones in Alberta.

Defoliation caused by eastern spruce budworm, (*Choristoneura fumiferana*) in 2014 was confined to the Lower Peace Region. The budworm-defoliated area remained relatively low at about 70,935 hectares. There was no severe defoliation in 2014, only moderate defoliation.

Western spruce budworm (*Choristoneura occidentalis*) populations in southwest Alberta collapsed in 2012. Consequently, there was no aerially visible defoliation caused by this agent.

In 2014, the gross area of aspen defoliated by forest health damaging agents decreased to half of that observed in 2013, at 3,586,005 hectares. The forest tent caterpillar (*Malacosoma disstria*) and aspen twoleaf tier (*Enargia decolour*) caused almost all of aspen defoliation in 2014; large aspen tortrix (*Choristoneura conflictana*) contributed a negligible amount.

The red-band needle blight of pine (*Dothistroma septosporum*) was confirmed on high value pines growing at the Alberta Tree Improvement and Seed Centre (ATISC) as well as in a pine species-provenance trial at the Calling Lake experimental test site in 2013. In 2014 red-band needle blight was also confirmed near Blue Ridge Alberta. In 2013 management of red-band needle blight was undertaken in the high value pine clone bank at ATISC. A copper sulphate-based fungicide has been applied for two consecutive years. Health surveys were completed to determine the efficacy of the program which will continue into 2015.

Douglas-fir needle cast caused by the fungus *Rhabdocline pseudotsugae* was confirmed in a provenance trial at Diamond Hills on Douglas-fir in 2013. In 2014 this disease was also confirmed at Tershisner experimental test site in a provenance trial near Nordegg. There was a noted increase of pathogen outbreaks across the province in 2014.

Damage caused by abiotic agents in 2014 was significantly higher than in 2013. Among the abiotic agents affecting forest trees in 2014 were winter dessication, blowdown, drought, red belt and flooding.

In 2014, ATISC programs were very successful. The seed science program improved germination methods for whitebark pine, an endangered species, and determined that beaked hazel, a common shrub used in reclamation, is an orthodox species. 2014 had a small cone crop, typical after the bumper crop in 2013. Three hundred and forty nine new seedlots were collected in 2014, including some native shrubs. In total 826 kg of tree seed, and 6.88 kg of reclamation seed were withdrawn by industry to produce seedlings. Three new genetics trials were established in the province.

Forest Health Officers and technicians surveyed selected locations in the Green Area of the province to detect and monitor occurrence of invasive plant species. Surveys discovered three prohibited noxious species. This year hawkweeds, some of which are prohibited noxious weeds, posed serious challenges in the management of invasive plant species in the province. In 2014, ecological, mechanical and herbicidal treatments were used to manage invasive plant species.

Collaborative programs reported here include:

- Canadian Food and Inspection Agency gypsy moth trap deployment,
- Climate Impact on the Productivity and Health of Aspen plots,
- Whitebark pine and limber pine recovery plans,
- Terrestrial Environment Effect Monitoring Team of the Wood Buffalo Environmental Association, and
- Invasive Alien Species Trapping Program.

Introduction

This is a report on programs carried out by the Forest Health and Adaptation program of Alberta Environment and Sustainable Resource Development (ESRD) in 2014.

This report will address the many programs that make up Forest Health and Adaptation.

This report contains details of the following:

1. The mountain pine beetle (MPB) management program including results of surveys carried out by using aggregation pheromone-baited trees to detect long-distance aerial dispersal, results of aerial surveys carried out to detect pine trees with red crowns symptomatic of MPB attack, results of ground surveys to detect population trends, beetle-focused level-1 single tree treatment and the MPB reforestation seed inventory enhancement program.
2. The spatial distribution of defoliation, population trends, and the extent and severity of damage caused by the eastern spruce budworm as well as other conifer defoliators detected across the province.
3. The spatial distribution, extent, and severity of damage caused by major aspen defoliators.
4. Forest pathogen incidence and management, including red-band needle blight and Douglas-fir needle cast.
5. The spatial distribution and severity of damage caused by abiotic forest tree damaging agents.
6. The invasive plants program, including steps taken to increase awareness, ground survey results, and control programs carried out at selected sites in the Green Area.
7. Summary of programs specific to the Alberta Tree Improvement and Seed Centre (ATISC) including seed science, seed collections, tree improvement trials and plant propagation statistics.
8. Collaborative programs carried out in co-operation with other agencies.
9. Programs used to increase forest health awareness.

Forest pest-related data are reported on a regional basis. Appendix I shows the ESRD regions in Alberta in 2014.

The surveys reported in this document were carried out for program management purposes over forested Crown land across the Green Area of Alberta. These surveys do not necessarily cover the entire forested land base. Although every effort is made to ensure accuracy and completeness of this report, its integrity is not guaranteed by ESRD.

Forest Health Damaging Agent Conditions and Management Programs in 2013

Bark Beetles

Mountain Pine Beetle (*Dendroctonus ponderosae Hopkins*)

The details of the mountain pine beetle (MPB) management program reported here cover the 2013 beetle year from August 15, 2013 to August 14, 2014. This period coincides with MPB dispersal from host trees in the summer of 2013 followed by the completion of the life cycle and the emergence of adult beetles in the summer of 2014.

This report covers historical aspects of the current MPB outbreak and details of the following activities:

- detection and assessment of 2013 MPB infestations,
- actions taken to manage MPB infestations, and
- ground surveys carried out to forecast 2014/15 MPB population trends.

The objectives, principles and actions of Alberta's mountain pine beetle program are outlined in the Mountain Pine Beetle Management Strategy available at: http://esrd.alberta.ca/lands-forests/mountain-pine-beetle/.

Detection and Assessment of MPB Infestations

Long-Distance Dispersal Monitoring

Plots containing MPB aggregation pheromones were dispersed in pre-selected townships to determine beetle presence. These plot findings cannot be used to estimate population size. Traps were placed in highly susceptible stands in June 2013 and checked for the presence of MPB in September 2013.

Figure 1 shows the results of long-distance dispersal monitoring following the MPB flight of 2013. Plots were placed in the northwest corner of the province to detect beetle presence. Positive attacks were established in 2012 and 2013 at these sites indicating that beetles are present all way to the border of the Northwest Territories. In collaboration with Saskatchewan, the bait program was expanded east where in 2012 a positive attack site was located 50 km from the Saskatchewan border. This same site was hit in 2013.

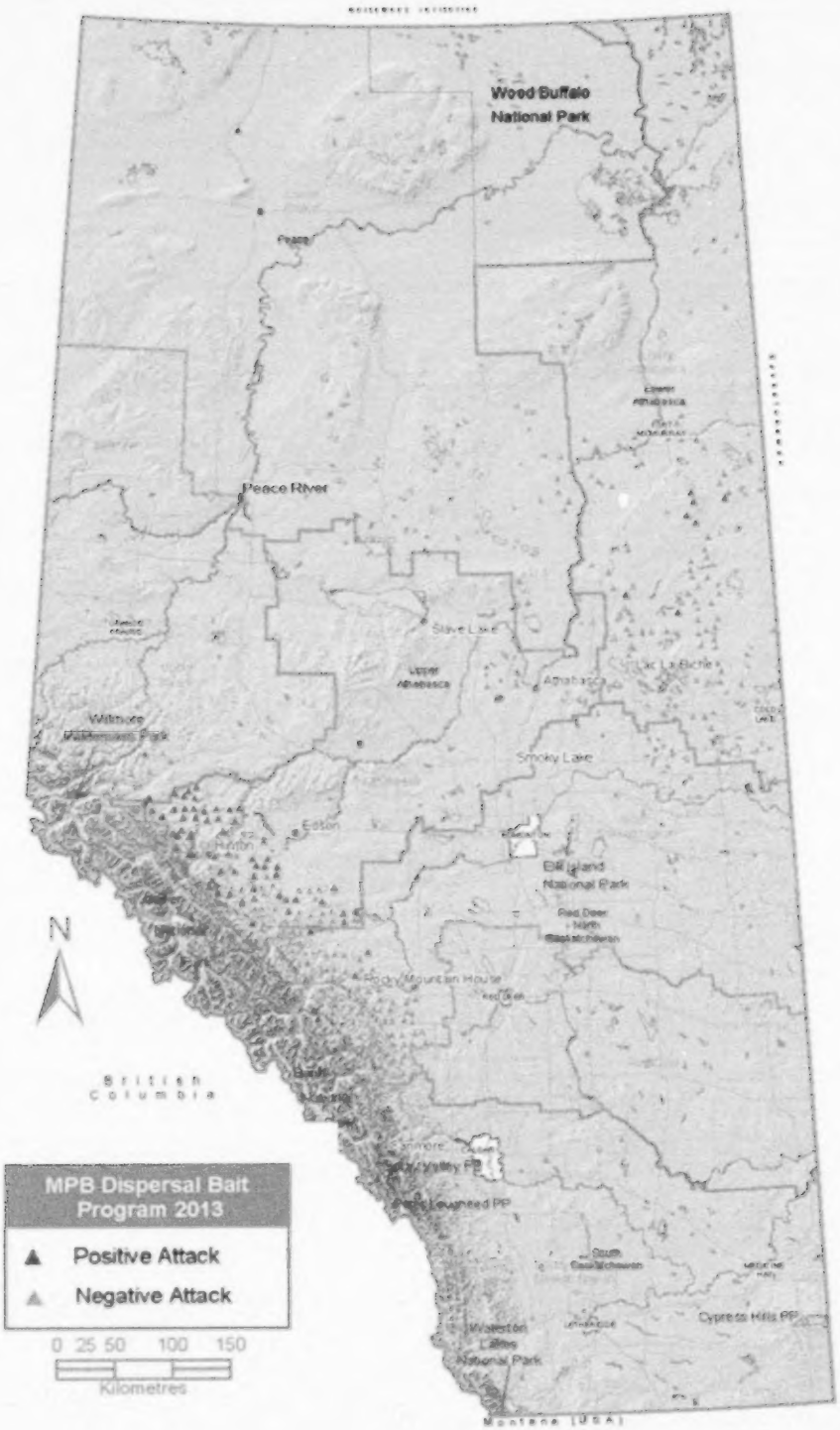


Figure 1. Map showing the results of pheromone-based long-distance dispersal monitoring of MPB for 2013 in Alberta.

Figure 2. Results of heli-GPS aerial surveys carried out over pre-selected areas in fall 2013.

Heli-GPS Surveys

From August 15 through September 15, 2013 heli-GPS surveyors recorded locations of pine trees with red crowns symptomatic of MPB infestations. These surveys covered areas that were determined as priorities for beetle control (Figure 2). Heli-GPS surveyed areas are in Figure 3. These surveys do not cover the same areas from year to year and are allocated to priority areas based on previous year data and infestation predictions.

The heli-GPS surveys detected 208,459 red trees suspected to have been killed by MPB in the areas slated for control. In most areas surveyed by heli-GPS, the number of trees detected increased from 2012.

Green:Red Ratios

The green:red ratios are the ratios of green attacks (trees with current year attacks still retaining green crowns) to red attacks (trees with red crowns attacked in the previous year). This ratio indicates the relative success of beetle populations and potential for their spread. A value of 1 means the population is stable, with equal numbers of current and previous year attacks; values below 1 mean beetle populations are decreasing in an area; values above 1 mean beetle populations are increasing in an area.

The green:red ratio surveys were carried out in early fall of 2013 at 619 sites (Figure 4). The results indicate that beetle populations are generally decreasing in the eastern and southern extent of the sample area, and over the majority of northwest Alberta. Results indicate a moderate to extremely high success rate of beetles in the area south of Grande Prairie, extending eastward in a band to Whitecourt, and at a number of localized areas in the northwest. In southern Alberta, local beetle populations have remained low since 2010, thanks to aggressive control efforts and a cold winter in 2009.

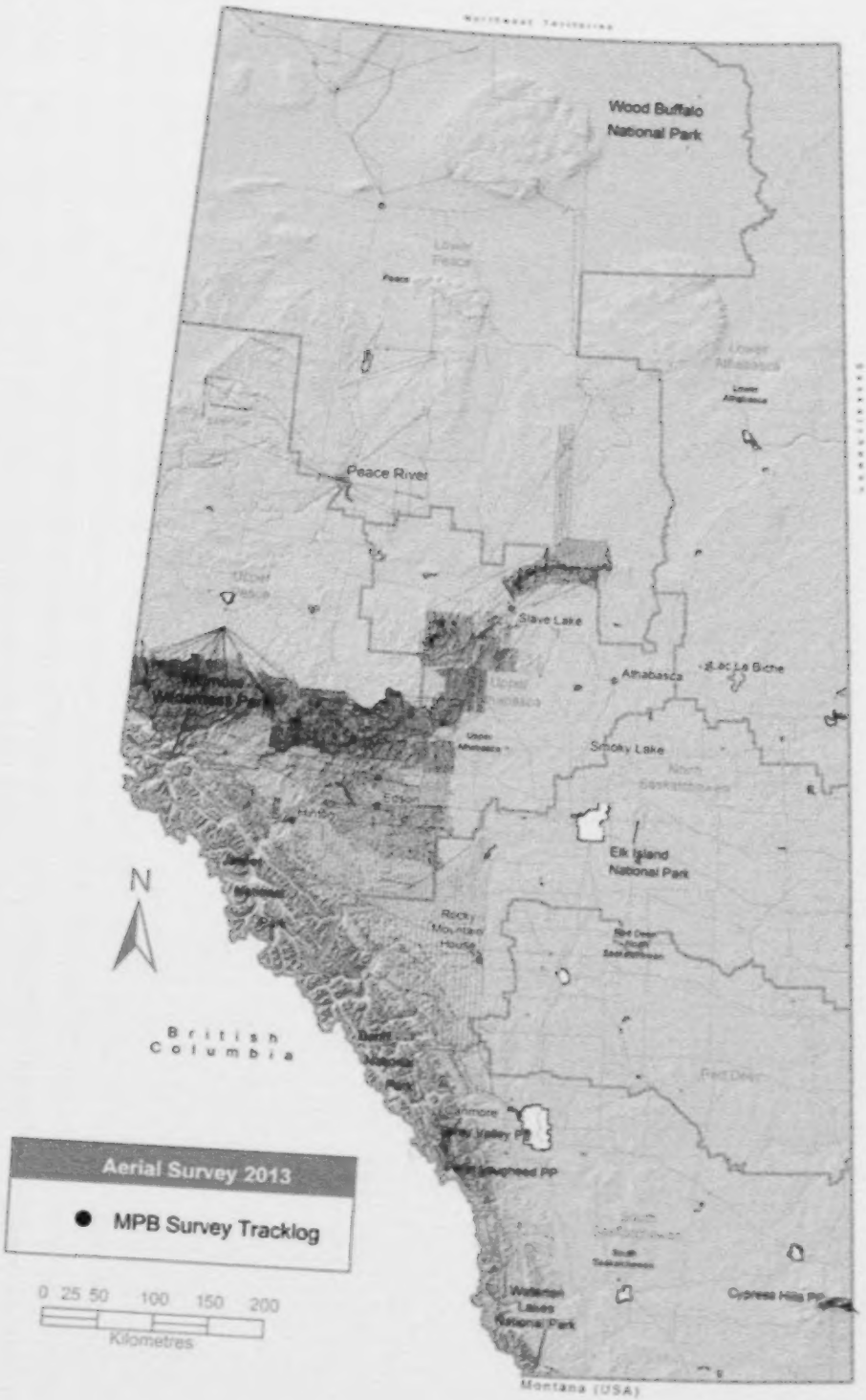


Figure 3. Map showing MPB heli-GPS track log for 2013 aerial surveys.

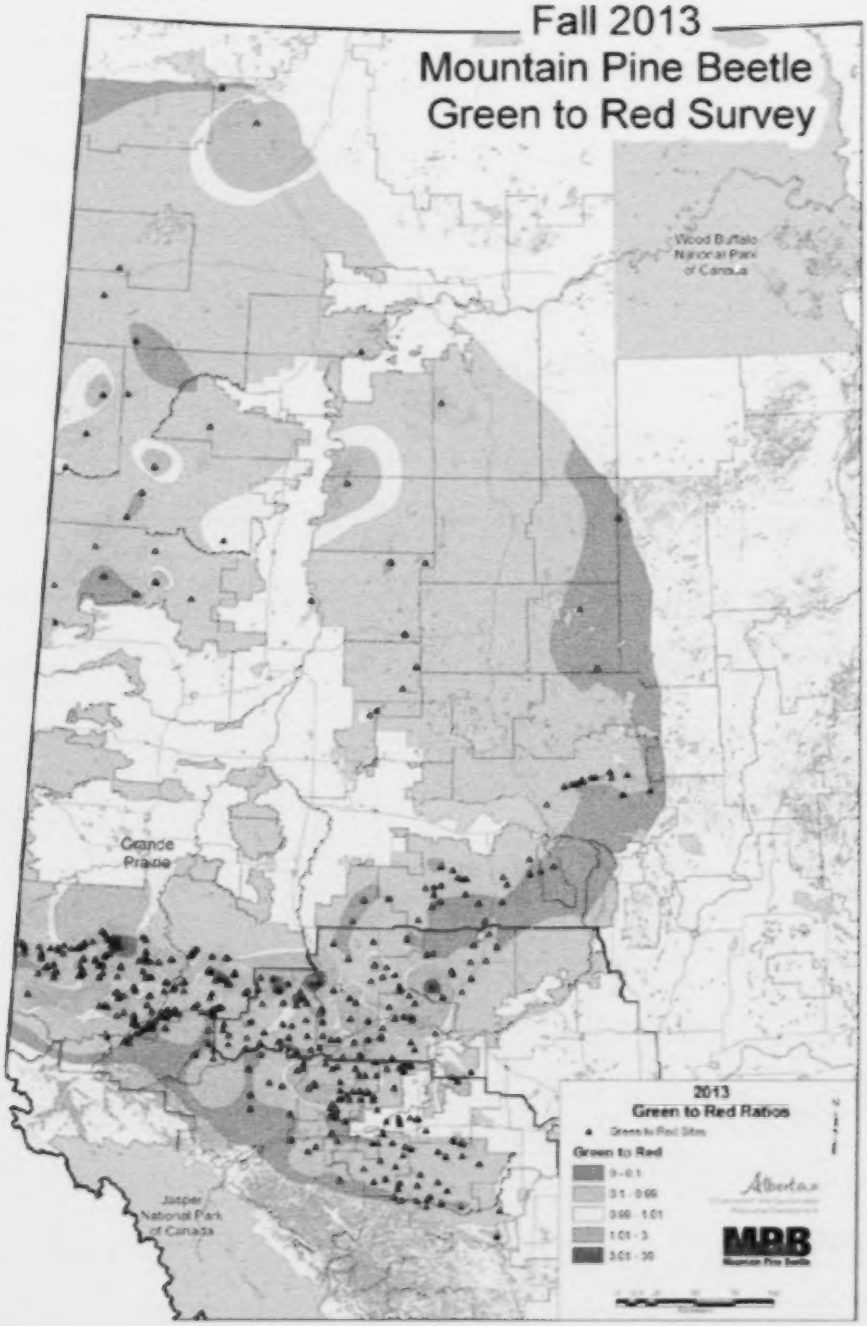


Figure 4. Map showing green:red ratio results from 2013.

Ground Surveys to Detect Green Attacks

Ground surveys were carried out at 17,492 sites in the fall of 2013 to detect high risk green attack trees for control in the Leading-Edge and the Active Holding zones. These surveys were based on locations of red attack trees that were detected during heli-GPS surveys. Altogether, ground surveyors detected 194,183 high risk green attack trees that were earmarked for control.

Infested-Tree Treatment Under the MPB Management Program

A Decision Support System (DSS) supported by a geographic information system (GIS) is used to prioritize sites with MPB-infested trees for survey and control. The DSS categorizes beetle-infested sites detected by heli-GPS surveys into five categories of MPB spread risk, varying from very low to extreme, based on beetle biology and stand characteristics. The goal is to survey and control trees at 80 per cent or more of the sites that are ranked as having moderate, high or extreme risk of spread within the Leading-Edge and Active Holding zones (Figure 5).

The MPB-infested trees were treated by:

- Level 1 single-tree control by ESRD, and
- single tree control by municipalities under an ESRD grant program.

Level 1 Single-Tree Control

ESRD awarded contracts to companies to conduct Level 1 tree control. Under this control program 167,900 MPB-infested pines were removed. Of these, approximately 34,000 infested trees were controlled by the forest industry under the Forest Resource Improvement Association of Alberta (FRIAA) MPB control grant. Since 2006 a total of 1,221,713 trees have been controlled. Figure 6 shows the extent of pine stands in Alberta that have been affected by MPB since 2006. This figure does not indicate current range but shows the cumulative effect of MPB on Alberta pine stands.

MPB Municipal Grant Program

ESRD administers a Municipal Grant Program that provides funding support for municipalities in the Leading Edge zone to conduct MPB management activities. During the 2013 beetle year, three municipalities removed 111 beetle infested trees, which is slightly more than in 2012. The municipalities involved in this program were the Town of Whitecourt, Woodlands County, and Yellowhead County.

Figure 5. MPB management zones in Alberta in the 2013 beetle year.

Figure 6. Cumulative presence of MPB attack on pine stands in Alberta since 2006.

Forecasting Population Trends

r-values

The r-value is a measure of the relative success of a MPB population. It measures the number of beetles attacking a tree versus the number of beetles that successfully develop and emerge from that tree to attack new trees. The projections for relative success of MPB populations, based on r-values calculated using the 2014 spring survey data, are shown in Figure 7. Figure 7 shows the projections for extremely successful beetle populations in red and those of highly successful beetle populations in orange. Both of these categories indicate increasing beetle populations. The projections for static MPB populations are shown in yellow and the projections for decreasing beetle populations are shown in blue. Based on r-values, the beetles in 2014 were relatively less successful (Figure 7), compared to the beetles in 2013 (Figure 8).

Mountain Pine Beetle (MPB) Reforestation Seed Inventory Enhancement Program

The MPB Reforestation Seed Inventory Enhancement Program was established in 2007 as a method to enhance seed supply for areas identified as high risk for MPB infestation. Collections were targeted in seed zones with insufficient seed supply. This program is carried out through the Forest Resource Improvement Association of Alberta (FRIAA) Mountain Pine Beetle Program Grant Agreement (MPBGA) funded by ESRD, as well as targeted collections by Forest Health and Adaptation seed collection contracts.

The MPBGA was designed to fund wild seed collections (Stream 1 seed) through FRIAA but also has provisions for proposals to make non-capital expansions to pine seed orchards to further enhance the supply of genetically improved (Stream 2 seed) reforestation seed. Since 2007 this program has collected 4,866 kg of lodgepole pine seed, representing 131 seedlot collections from 23 seed zones.

Forest Health and Adaptation MPB Stream 1 operational reforestation collections started in 2008/2009. Forest Health and Adaptation staff chooses collection sites with low lodgepole pine seed supply, low probability for collection by industry, and high MPB attack risk. ESRD then contracts out seed collections for the identified areas. Forest Health and Adaptation contract ground and aerial collections have been made from 46 different seed zones collecting 2,574 kg of seed.

FRIAA aerial seed collection.

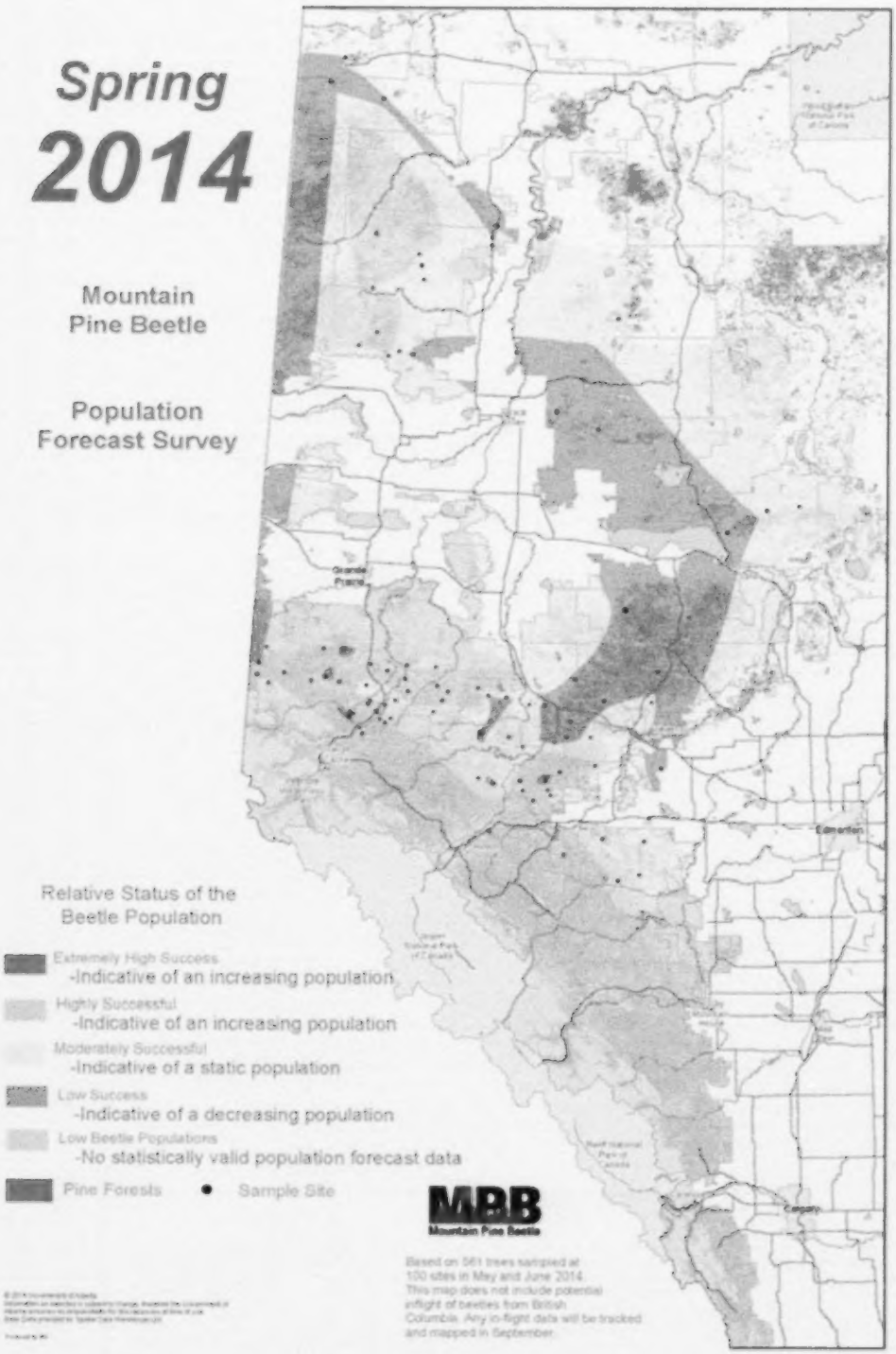


Figure 7. Projections of relative success of MPB populations in 2014, based on the r-values calculated using 2014 spring survey data.

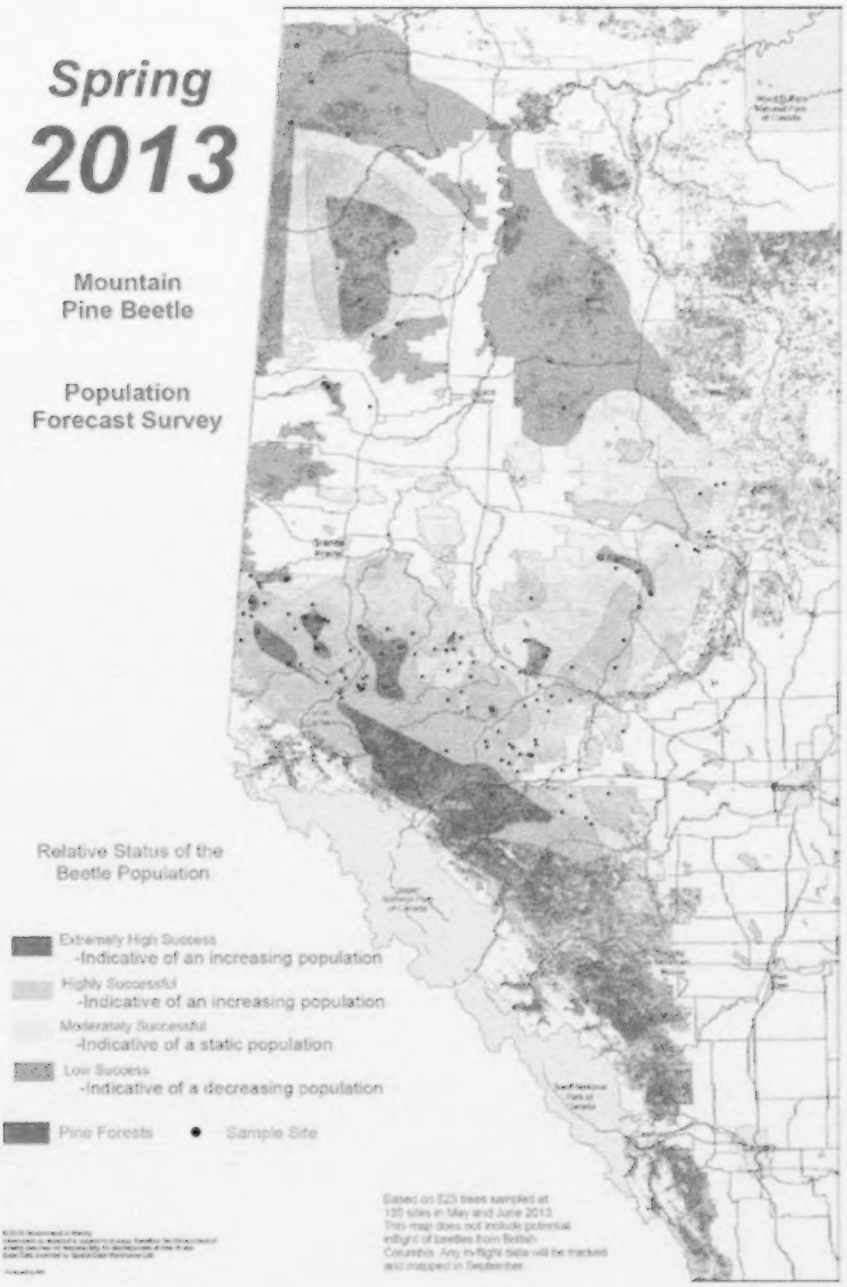


Figure 8. Projections of relative success of MPB populations in 2013, based on the r-values calculated using 2013 spring survey data.

Eastern Larch Beetle (*Dendroctonus simplex*)

Eastern larch beetle was identified and mapped in the North Saskatchewan Region in eleven tamarack stands west of Drayton Valley in 2013. In 2014, 33 stands were infested with eastern larch beetle, the majority west of Drayton Valley and a few near Rocky Mountain House. The increase between 2013 and 2014 was due to improved expertise on aerial identification of this agent.

Polygons were drawn around infested stands to estimate percent infestation (Figure 9). One 28 ha stand was 80 per cent infested, 17 stands (total 282 ha) were 10-30 per cent infested, and 15 stands (total 110 ha) were 1-5 per cent infested. The stand with 80 per cent infestation has likely been infested for 5 years, the stands with 10-30 per cent infestation have had multiple years of attack, and stands with 1-5 per cent infestation are newly infested.

Eastern larch beetle adults.

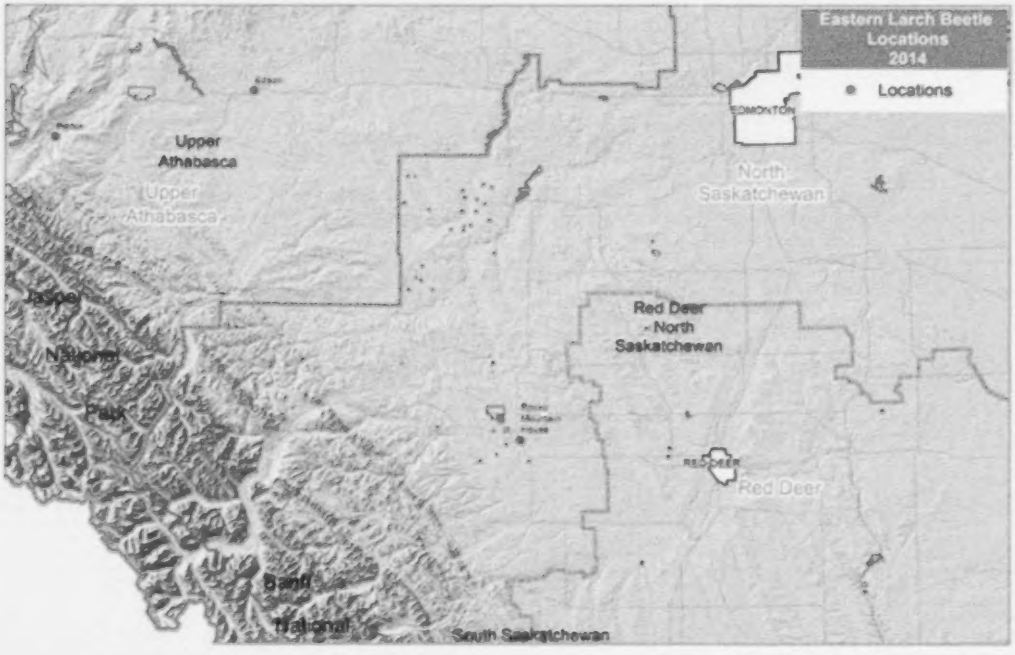


Figure 9. Easten larch beetle observations 2014.

Spruce beetle (*Dendroctonus rufipennis*)

Spruce beetle was identified in both the Upper Athabasca Region and the North Saskatchewan Region. Damage done by spruce beetle in the Upper Athabasca Region was detected by local landowners who contacted the regional Forest Health Officer. Both locations were near Widewater, 20 km west of Slave Lake. The trees were removed and burned. In the North Saskatchewan Region the extent of damage was greater. Infestations were found scattered from Range 10 west to Range 16, and from Township 40 north to Township 43. Helicopter flights were used to delineate infested stands (Figure 10), which totalled 650 ha. Forest health staff will continue to monitor these areas carefully while a management plan is developed.

Spruce beetle infested stand.

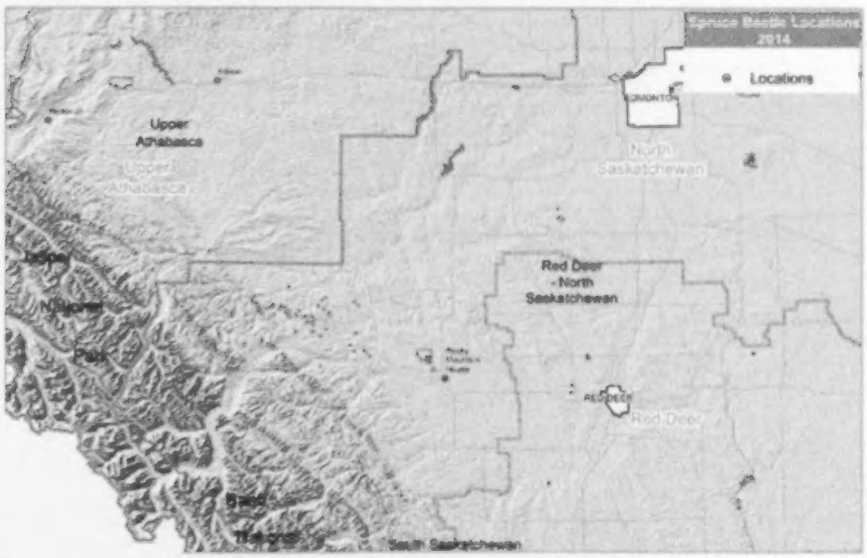


Figure 10. Spruce beetle observations 2014.

Conifer Defoliators

Eastern Spruce Budworm (*Choristoneura fumiferana*)

The eastern spruce budworm is a native defoliator that has co-evolved with white spruce and balsam fir. Over the last 50 years, eastern spruce budworm infestations have occurred mainly in river valleys of northern Alberta, while infestations in southern Alberta are rare.

Forest Health Officers annually conduct aerial surveys to detect and assess eastern spruce budworm-defoliated stands on forested Crown land. The goals of this program are:

- to keep a historical record of these infestations, and
- to assess the need to take management action if spruce budworm infestations could compromise the land management objectives.

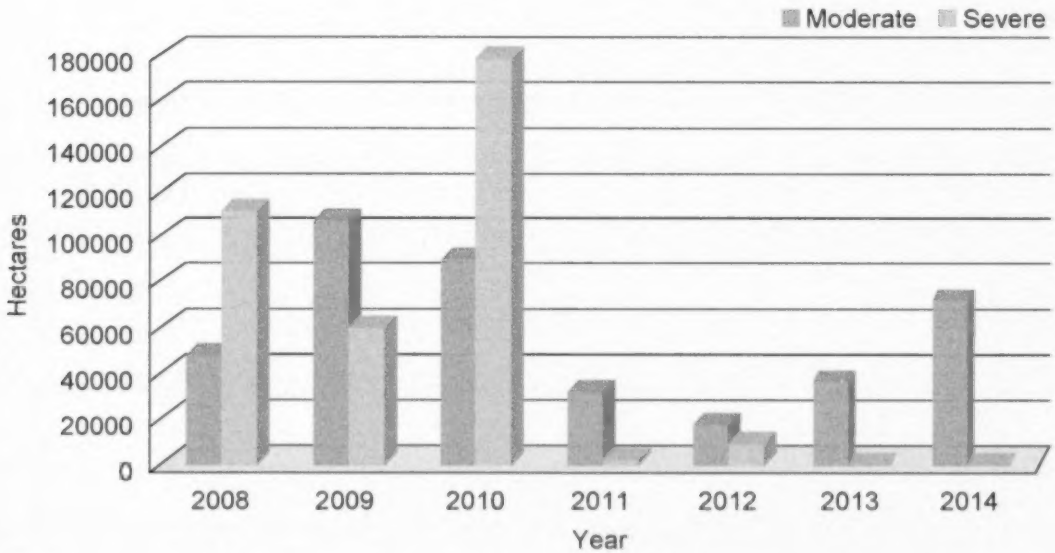


Figure 11. Areas of moderate and severe eastern spruce budworm defoliation in aerially surveyed areas of Alberta, 2008–2014.

Figure 11 shows the results of the 2014 overview aerial surveys carried out to detect and assess eastern spruce budworm infestations. In 2014, visible defoliation was confined to the Lower Peace Region in northern Alberta (Figure 12), covering an estimated net area of 70,935 ha, all of which was moderately defoliated (Table 1, Figure 11). There was a 91 per cent increase in the budworm-defoliated area in 2014 over 2013.

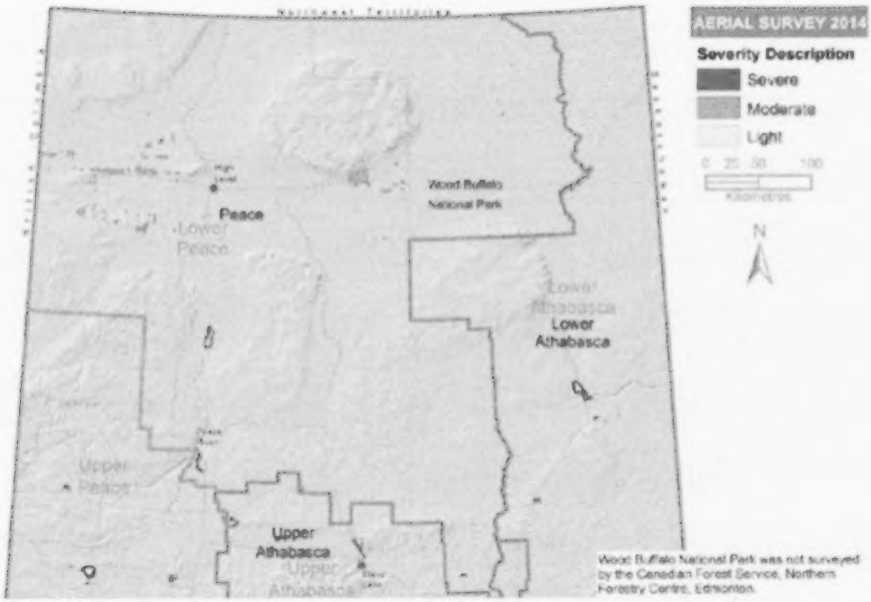


Figure 12. Spatial distribution of aerially visible eastern spruce budworm defoliation over forested Crown land surveyed in 2014.

Table 1. The extent (hectares) of eastern spruce budworm defoliation recorded under each severity category during overview aerial surveys carried out in Alberta in 2013 vs. 2014

Severity Category[1]	2013	2014	Percent Change from 2013 to 2014
Moderate	37,196	70,935	91
Severe	0	0	0
Total	37,196	70,935	91

[1] moderate: ≤70 per cent of new foliage defoliated; severe: >70 percent of new foliage defoliated

Other Conifer Defoliators

Western Spruce Budworm (*Choristoneura occidentalis*)

Western spruce budworm populations in southern Alberta collapsed in 2012. Aerial observations detected no visible defoliation caused by this pest in 2014.

Spruce Spider Mite (*Oligonychus ununguis*)

Spruce spider mite was identified in 2014 by Forest Health Officers in the Lower Peace Region and the Upper Athabasca Region. Damage by this agent consists of needle desiccation and early needle drop on spruce trees. All cases were first noticed by local landowners and damage was minimal.

Broadleaf Defoliators

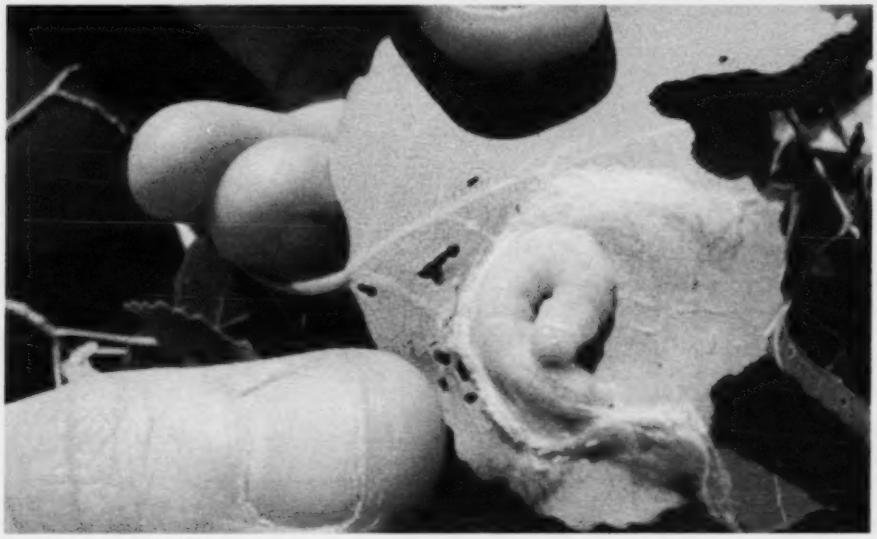
Aspen Defoliators

Forest Health Officers and/or technicians carry out annual overview aerial surveys to record the gross area affected by aspen defoliation. Severity categories are no longer used as these categories have limited accuracy since aerial surveys are done once a year and only capture a snapshot of the defoliation season.

The objective of these surveys is to maintain a historical record of damaging agent-caused aspen defoliation over the Green Area to enable forest health practitioners to follow the long-term trends of aspen defoliation in relation to changes in biological and environmental factors. These surveys also highlight a status change of innocuous agents into forest health damaging agents. In addition, these surveys provide data to assess the impact of these damaging agents and to decide on the need to take control action if their impacts are compromising forest management objectives. These records are used in compiling a national database on incidence and impacts of pests across Canada.

Figure 13 shows the spatial distribution of aspen defoliation over the aerially surveyed parts of the Green Area. In 2014, 3,586,005 ha of aspen defoliation was recorded. This is nearly half the area recorded in 2013. The forest tent caterpillar was the dominant defoliator of aspen in 2014, affecting 3,294,041 ha. The aspen twoleaf tier was the second largest cause of defoliation in 2014, affecting 295,089 ha, half the area it defoliated in 2013. The only other aspen defoliator observed in 2014 was large aspen tortrix (Table 2).

The majority of aspen defoliation occurred in the Lower Peace Region and the Upper Peace Region in 2014 (Table 3).



Aspen twoleaf tier larva.

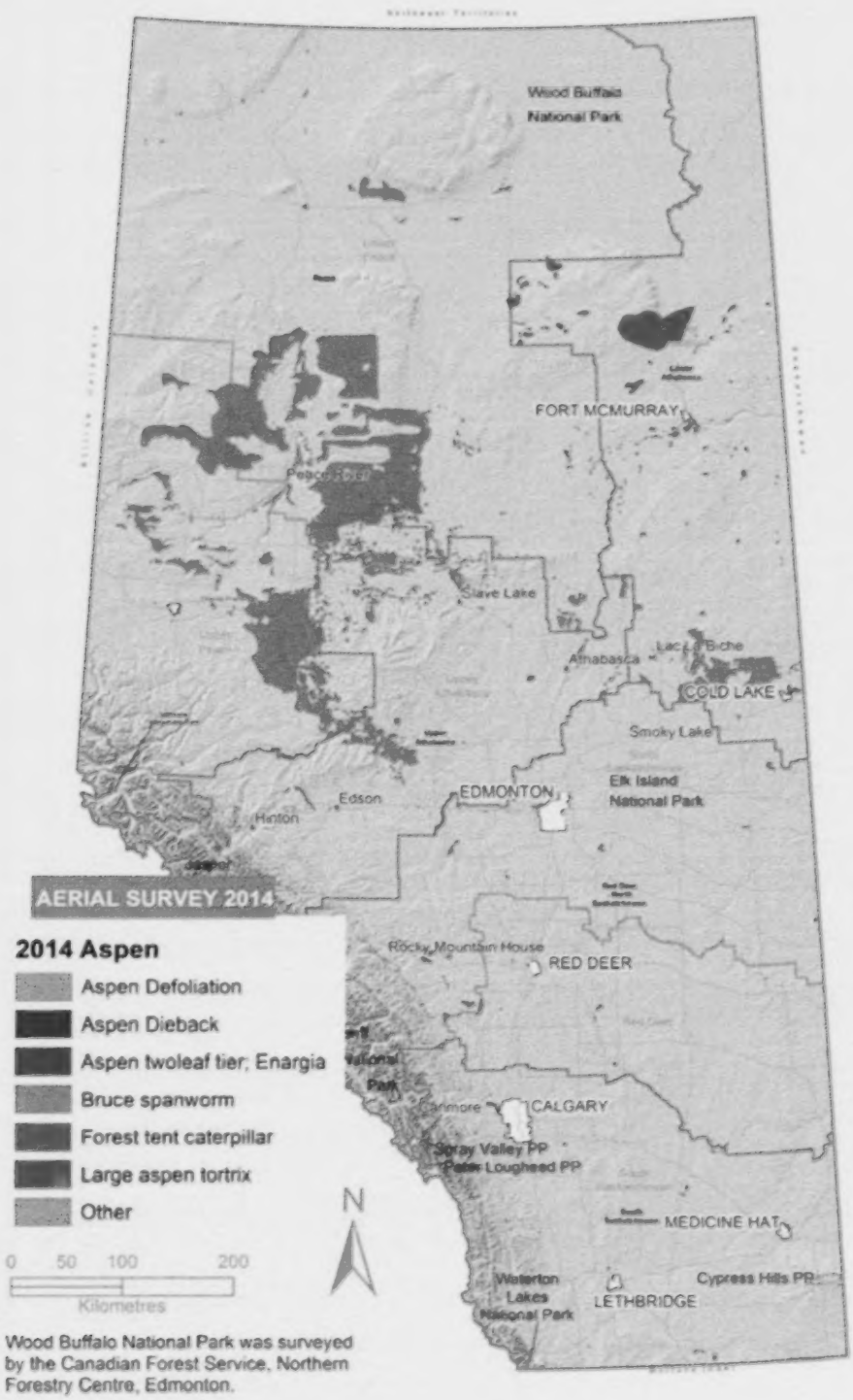


Figure 13. Spatial distribution of aerially visible, forest health damaging agent-caused aspen defoliation and dieback recorded during 2014 aerial surveys of the Green Area.

Table 2. The extent (hectares) of aspen defoliation in 2014 by agent in Alberta.

Pest	Total Defoliation
Forest Tent Caterpillar	3,294,041
Large Aspen Tortrix	1,389
Aspen Twoleaf Tier	295,089
TOTAL	**3,590,519**

Table 3. The extent (hectares) of aspen defoliation in the corporate regions of Alberta, 2013 vs. 2014

Region	Total 2013 Area (ha)	Total 2014 Area (ha)
Lower Peace	3,374,837	1,557,764
Upper Peace	1,171,896	1,004,002
Lower Athabasca	1,230,375	500,960
Upper Athabasca	427,740	502,230
North Saskatchewan	108,289	21,851
South Saskatchewan	2,080	1,544
TOTAL	**6,215,218**	**3,588,351**

Other Broadleaf Defoliators

Leaf Beetle Species (*Chrysomela* spp.)

In the Lower Peace Region browned willows were found during aerial surveys as well as ground truthing. Skeletonized leaves on aspen were noted during Climate Impacts on the Productivity and Health of Aspen (CIPHA) plot data collection, as well as during ground truthing. The Forest Health Officer in the Lower Peace Region identified the agent causing the damage to be *Chrysomela* spp. *Chrysomela* species are beetles that attack poplar, aspen and willow. They kill leaders and young foliage but do not cause long term damage.

Willow Leafminer (*Micruapteryx salicifoliella*)

Willow leafminer caused widespread and extensive defoliation of willows throughout the Lower Athabasca Region in 2014. Willow leafminer does not cause extensive mortality in stands of willow, however successive years of defoliation can cause willow die-back. Public outreach done by ESRD beginning in 2011 has alleviated the number of calls to the department from concerned citizens regarding this pest. An information leaflet regarding this pest was developed in 2012 and can be obtained from local ESRD offices.

Diseases

Red-band Needle Blight of Pines (*Dothistroma septosporum*)

Red-band needle blight was identified in a pine clone bank at ATISC in Smoky Lake as well as in a pine provenance trial located near Calling Lake in 2013. In 2014 another site located near Blue Ridge was also confirmed as infected with red-band needle blight. The identification was confirmed by Dr. Tod Ramsfield (pathologist) and Colin Myrholm (pathologist technician), with the Canadian Forest Service.

Due to the high value of the pine clone bank at ATISC and the severity of the infection, a management strategy was implemented to reduce loss of genetic material in 2013. The infected trees were treated in 2013 and 2014 with Bordeaux mixture, a copper sulphate-based fungicide. Treatments were applied in May to reduce inoculum potential and again in July to protect fully erupted needles. Surveys were done in early May to analyze the efficacy of the previous year's program and monitor tree health.

The 2013 and 2014 health surveys determined that the severity of the outbreak in the pine clone bank did not increase substantially from 2012 to 2013. The data showed a 4-12 per cent decrease in healthy foliage percent from 2012 to 2013 (Figure 14). The 2014 survey assessment was likely skewed by several factors, particularly the presence of pine needle cast (*Lophodermella concolor*). Pine needle cast attacks new growth and produces symptoms in the year following the attack. The symptoms are impossible to distinguish from those caused by red-band needle blight. Another possibility of apparent lower infection rates in 2012, is the presence in May 2013 of needles infected in 2012 showing both, necrotic and green tissues thus making an impression of a greater amount of healthy foliage. These infected needles fell off later in 2013, thus affecting the assessment in May 2014. The determination that the severity of red-band needle blight has stabilized is supported by the fact that no *D. septosporum* infections were detected in the samples collected on May 20-22, 2014. The efficacy of the treatments will continue to be evaluated.

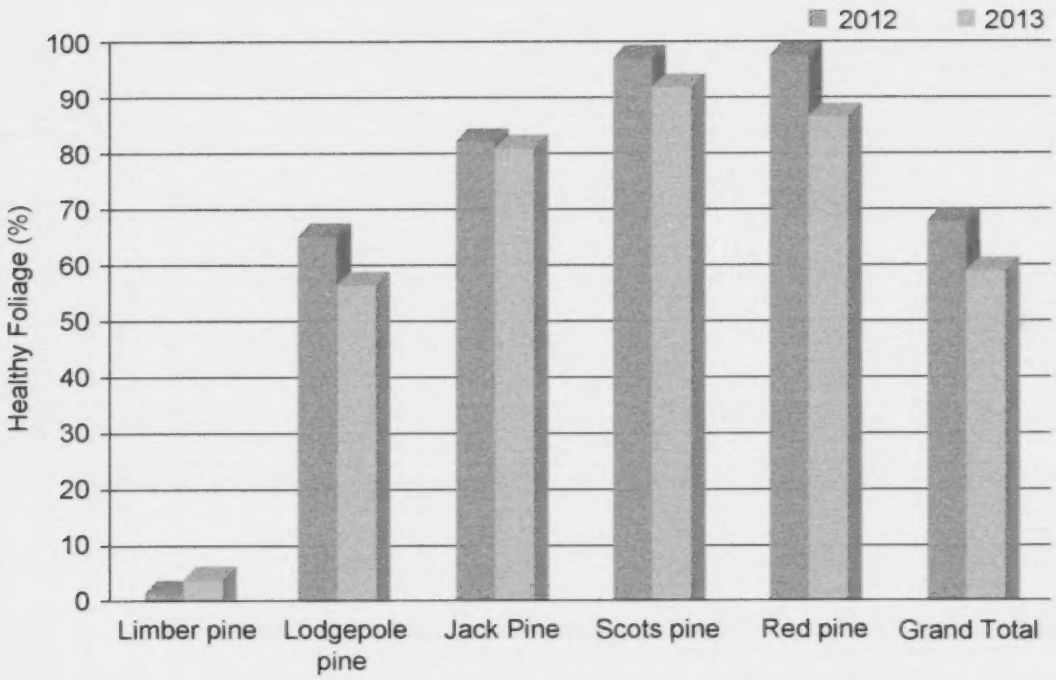


Figure 14. Percent healthy foliage by species following red-band needle blight infection in ATISC pine clone bank G206A.

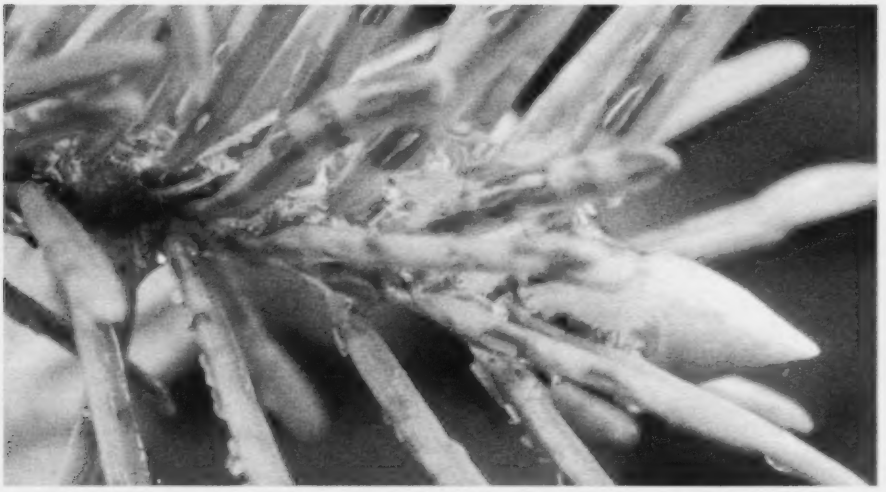
In 2014 the red-band needle blight management program was expanded. Surveys were completed at Calling Lake provenance trial to determine the effects of the pathogen on different species and provenances.

The University of British Columbia was hired to determine which species of red-band needle blight is in Alberta, and if it is genetically unique to the province or similar to that in British Columbia. This information will be delivered in 2015.

Forest Health Officer completing health survey on pine infected with red-band needle blight at Calling Lake genetic test site.

Douglas-fir Needle Cast (*Rhabdocline pseudotsugae*)

Rhabdocline pseudotsugae is a fungal pathogen of Douglas-fir. Douglas-fir needle cast occurs widely in the northwestern United States and British Columbia. This pathogen only affects Douglas-fir and causes chlorotic foliage and very thin open crowns. Until its positive identification by Dr. Tod Ramsfield and Colin Myrholm of the Canadian Forest Service at the Diamond Hills genetic test site near Rocky Mountain House in 2013, Douglas-fir needle cast had not previously been described in Alberta. In 2014 Dr. Tod Ramsfield and Colin Myrholm positively identified Douglas-fir needle cast at the Tershishner genetic test site near Nordegg from samples collected by Forest Health and Adaptation staff doing a routine inspection. The effects of this disease will be monitored through routine trial measurements.



Douglas-fir needle cast apothecia erupting through needle epidermis on Douglas-fir at Tershishner genetic test site.

Other Diseases

Large Spored Spruce Labrador Tea Rust (*Chrysomyxa ledicola*)

Spruce trees across the Lower Athabasca Region were infected with large spored spruce labrador tea rusts. These rusts are common for boreal conifers and tend to be more common in years with wetter springs, with 2014 being a heavy infection year. Trees in some areas were so heavily infected that they were identified during aerial overview flights as having spruce budworm-caused defoliation, but ground truthing showed these areas were actually affected by spruce needle rusts. ESRD staff received many calls from concerned people reporting discoloured spruce trees or, in some instances, "orange goo" floating on lakes and rivers.

Two species of large spored spruce labrador tea rust are prevalent in Alberta, *Chrysomyxa ledi* (C. *Ledi*) and *Chrysomyxa ledicola* (C. *ledicola*), which are closely related and difficult to distinguish. The exact species in the Lower Athabasca Region in 2014 was not identified. Needle rust fungi have complex lifecycles producing copious amounts of orange spores at various stages, both on the affected trees and the alternate host, labrador tea. The sporulation largely accounts for the discolouration on the trees and can be blown by the wind, accumulating in water bodies to form the "goo" that was reported by the public. Spruce needle rusts infect current year needles, causing premature needle drop. The damage they cause is largely cosmetic and even extremely heavily infected spruce tends to recover with few long-term effects.

Fungal Foliar Diseases of Pine

Fungal foliar diseases also affected pine trees in northeast Alberta in 2014. Many concerns from the public were received by ESRD regarding premature needle drop and reddening needles on pines on residential and recreational sites. The extent to which trees in the region were affected was not quantified; however, reports were widespread. In most instances pine needle cast (*Lophodermella concolor*) appeared to be the cause. In June, Alberta Parks staff from the Lower Athabasca Region expressed concern that younger, previously healthy pine at the North Buck Lake Provincial Recreation Area appeared to be dying. The campground was visited by the Forest Health Officer who observed many severely infected pines, in particular planted lodgepole pines. This disease can reduce growth, and cause mortality in the most severe cases. Forest health staff will work with parks staff in 2015 to ensure the worst affected trees are monitored and/or treated to preserve aesthetic values in the campground.

Large spored spruce labrador tea rust on a white spruce.

Early Defoliation and Browning of Poplar (*Marssonina populi*) spp.

For the last couple of years many of the poplars in the Lower Athabasca Region have been turning brown in early to mid-August. Browning leaves and early leaf senescence was evident over much of the region in 2014. Researchers from the Canadian Forest Service paid a visit to Athabasca and surrounding area in August. They determined leaf spot disease (*Marssonina populi*) was responsible for most of the damage observed.

Early defoliation and browning of poplar.

Other Biotic Agents

Lodgepole Pine Dwarf Mistletoe (*Arceuthobium americanum*)

Lodgepole pine dwarf mistletoe is a parasitic plant that infects pine in Alberta. The infection reduces growth rate and in rare severe cases, death. In 2014, aerial surveys detected 8,718 hectares of infected pine. Most of the pine infected was in the Lower Peace Region, Upper Athabasca Region and the Lower Athabasca Region. The level of severity of infection was variable.

Dwarf mistletoe infected jack pine.

Table 4 shows the amount of visible damage caused by various abiotic agents over the Green Area based on overview aerial surveys in 2012, 2013 and 2014. The total area affected by various abiotic agents in 2014 was higher than in 2013.

Table 4. The extent (hectares) of abiotic damage by agent over the last three years in Alberta

Year	Abiotic Damage Agent (ha)					
	Total	Blowdown	Drought	Flooding	Hail	Redbelt
2014	42,952	2,693	34,852	1,233	0	4,174
2013	2,997	1,679	348	970	0	0
2012	45,113	1,106	42,239	301	648	819

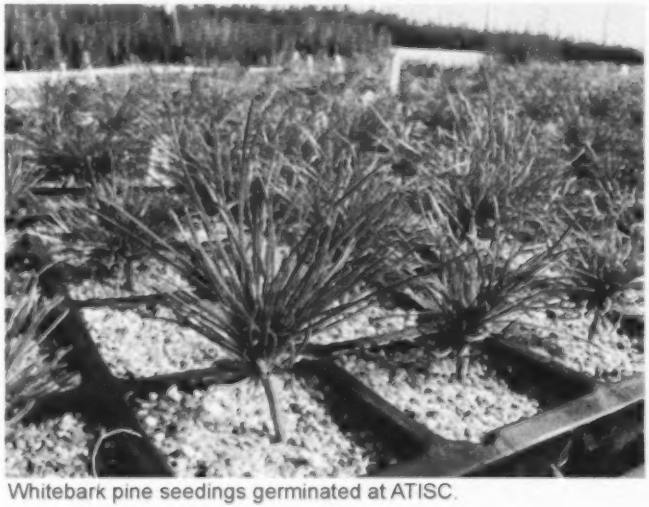
The increased incidence of redbelt was in the South Saskatchewan Region. Areas hit included the north side of the Bow Valley, the east side of the Kananaskis Valley, and on both sides of the Powderface Trail north of the Elbow River. Winter dessication was not recorded during aerial surveys but it was observed in the South Saskatchewan Region on the east side of the Ghost area and the east side of the Porcupine Hills based on ground truthing.

Alberta Tree Improvement and Seed Centre (ATISC) Programs

Seed Science

The Forest Health and Adaptation seed technology program endeavours to further Alberta's knowledge of seed science in order to provide best practices for seed bank management services and advice. While the white spruce mast cone year in 2013 required a lot of staff time to manage orchards and pick and process cones, the program also studied germination methods and seed storage practices for some tree and shrub species in Alberta.

Whitebark pine is an endangered species in Alberta mainly due to white pine blister rust (*Cronartium ribicola*), mountain pine beetle (*Dendroctonus ponderosae*) and limited natural regeneration due to fire suppression practices. White pine blister rust resistance screening and outplanting trials are currently being planned. In preparation, the Forest Health and Adaptation Seed Technology Program began collecting cones and storing seed in 2007. Existing germination methods from other jurisdictions did not produce acceptable results using Alberta seed and often required excessive labour and equipment. A germination trial was conducted by the seed program in 2013/14 using seed from three whitebark populations across the Alberta range. The results provided germination protocols that consistently achieve 90-100 per cent germination of viable seeds within 7 days at germination conditions. This germination method nearly doubles the total germination and it happens faster, which means cheaper and easier seedling propagation. With good germination protocols established, work has now begun on furthering the understanding of cold storage seed longevity for whitebark and limber pine, supporting our progress towards fulfilling conservation plans for endangered whitebark pine in Alberta.



Whitebark pine seedings germinated at ATISC.

In past years, local nurseries have had difficulties supplying beaked hazel seedlings (*Corylus cornuta*) for oil and gas reclamation projects because of poor seed germination. Due to a lack of understanding, the problems with producing sufficient seedlings in the past have been explained by suggesting the seed is 'recalcitrant' - meaning it will not survive drying and therefore cannot be cold stored under the same conditions as our regular 'orthodox' tree seed. Beaked hazel's seed storage behaviour is currently listed as 'indeterminate', which in this case means that the evidence is inconclusive. Therefore, a standard storage behaviour test was run on beaked hazel seeds collected in August 2013 and the results showed

that beaked hazel seeds are orthodox. The inconclusive and anecdotal evidence to the contrary can be explained by looking at current beaked hazel harvest practices. The beaked hazel seeds are most often collected too early in order to avoid squirrel predation. The problems with poor or no germination encountered by nurseries are due to this collection of immature seed that has not yet gained desiccation tolerance or maximum storage longevity; these are two of the last qualities achieved before full seed maturity and natural dispersal. The results of the trial support the proposed development of beaked hazel orchards in the future to produce Stream 2 or orchard seed. In this setting mature seed could be collected and predation would be controlled by netting and squirrel territorial behaviour, as happens in commercial beaked hazel production.

Beaked hazel seed germinating.

A formal seed storage monitoring program was initiated at ATISC in 1981 to test a sample of the total research and conservation seed lots in cold storage and monitor the quality of the seed. To date, ATISC has collected germination data spanning 35 years on seed lots comprising 13 tree species. This data was analysed in 2014 and we can now more accurately project the expected usable lifespan of many cold-stored tree species. The results also highlighted issues and ways to improve seed collection and handling. The purpose of the program has been modified to reflect our need to predict future storage time averages rather than monitor past efforts. Most previous seed lots have now been removed from the program and new ones added to further improve our understanding of economically important tree species, as well as those that may become more important in the future due to climate change. In addition, the changes to the program will help to fill the knowledge gap surrounding other non-economically important and endangered native Alberta trees.

Seed Collections

In 2013 ATISC had a record cone crop which resulted in 2014 having a very small cone crop, with some orchards having no cones at all. Table 5 outlines the amount of seed added to the ESRD inventory under different programs and for different species both wild and orchard.

Table 5. Weight of seed collected by seed collection method 2014.

Seed Collection Type[1]	Weight of Seed (kg)
FRIAA MPB Rehabilitation lodgepole pine wild seed collections	422
Contract MPB wild pine seed collections (Pl, Px and Pj)	464
ESRD MPB wild pine seed collections (Pl, Px and Pj)	0.83
ESRD owned CPP program orchard seed collections (Sw, Sb, Fd, Lw)	2.41
ESRD partnership CPP program orchard seed collection shares (D-Sw, G2-Sw, E1-Sw, C-Pl, K1-Pl, J-Pl, P1-Pj)	5.96

[1] FRIAA: Forest Resource Improvement Association of Alberta; Pl: lodgepole pine; Px: hybrid lodgepole-jack pine; Pj: jack pine; Sw: white spruce; Sb: black spruce; Fd: Douglas-fir; Lw: western larch: CPP: controlled pollination program – codes in this section refer to breeding zones for each species

In 2014, 349 new seedlots representing 64 different species were received at ATISC for registration and storage. Reclamation species are in high demand for the oil and gas industry adding 208 collections made from 57 shrub, grass and forb species for a total of 61.5 kg of seed. Seed collection of tree species still exceeds that for shrubs, grasses and forbs with 141 new collections, adding 1,345 kg of seed to the provincial inventory.

Seed withdrawal over the course of the year saw 826 kg of tree seed shipped to nurseries for production to meet orders for over 111 million seedlings. As well, 6.88 kg of seed for species other than trees were withdrawn for production of about 187,000 seedlings.

Cones picked from ATISC orchards.

Tree Improvement Trials

Three tree improvement trials were established in 2014; two Region J lodgepole progeny trials and one somatic embryogenesis trial including limber pine, lodgepole pine, and whitebark pine. The lodgepole pine trials, comprised of a total of 7,735 trees, were planted in Zama Ridge and Hotchkiss River genetic test sites. The embryogenesis trial was established at the ATISC, Smoky Lake with 110 trees.

Progeny trials are established to determine which "mother" trees produce the best offspring. Somatic embryogenesis is one method to enhance production of selected families or rare genotypes.

Plant Propagation

In 2014, 31,575 seedlings were grown at the ATISC, of which 5,720 were rootstock consisting of white spruce, lodgepole pine, jack pine, Douglas-fir, and western larch that will be used for grafting in 2016. The remaining 25,855 seedlings consisted of lodgepole pine for Region J progeny trial and white spruce for Region E1 progeny trial which will be planted in 2015.

Grafting is a major part of the plant propagation program. In 2014, 1,616 grafts were completed. Most grafting done was for the clone bank; 45 new clone selections were made. Due to the recent outbreaks of red-band needle blight and Douglas-fir needle cast in genetic trials, grafting was used to try and save genetic material from infected individuals by removing healthy material from infected individuals and grafting the healthy material to healthy rootstock. In 2013, all attempts to graft individuals infected with red-band needle blight were unsuccessful. In 2014, 50 per cent of the grafts from red-band needle blight infected individuals were successful. In 2014, the first round of grafting Douglas-fir infected with Douglas-fir needle cast was completely successful. Scions from the infected Douglas-fir had all their needles removed to minimize inoculum potential.

White spruce seedlings for progeny trials.

Invasive Plant Species Program in 2014

This program covers invasive plant species detection, surveys and management in the Crown land portion of the Green Area. Relatively large areas with either noxious or prohibited noxious invasive plants growing on Crown land are the main focus of this program. Early detection and rapid response are integral for prompt mitigation of new or low-level invasive plant infestations found either on high value sites or on vacant Crown land.

The overall objectives of this program are to:

- Carry out surveys to detect and estimate the extent of noxious or prohibited noxious invasive plant species at selected sites in the Green Area.
- Manage invasive plants on ESRD occupied sites and on vacant Crown land, as required by the *Weed Control Act*.
- Initialize and/or continue localized weed cooperative projects with high probability of success over designated high value areas.
- Detect early and take rapid response to manage invasive plants that occur at relatively low levels and/or new infestations either on vacant land or on high value sites.
- Continue ongoing education and increased awareness initiatives.

Invasive Plant Detection and Distribution Surveys

Table 6 contains a list of invasive plant species that were observed during ground surveys carried out at selected sites in the Green Area in 2013. The survey sites included ESRD facilities such as cabins, campgrounds, wildfire bases and staging areas, and wildfire lookout tower sites as well as vacant Crown land, such as random camp sites, abandoned forestry roads and quad trails.

Ox-eye daisy

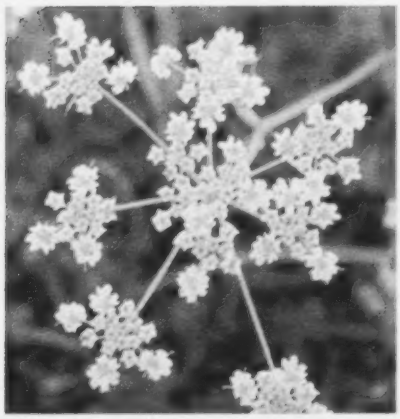
Figures 15-17 show occurrences of species of concern on Crown land within the Green Area monitored in 2014. These species are chosen for display as their distribution is limited and therefore more accurately portrayed. They are also the target of management efforts. These surveys did not systematically cover the entire Green Area but data is indicative of likely distribution.

Table 6. Invasive plant species observed during ground surveys carried out over selected sites in the Green Area in 2014

Common Name	Scientific Name	Occurrence[1]
Blueweed	*Echium vulgare*	1, 2
Burdock	*Arctium sp.*	1
Canada thistle	*Cirsium arvense*	1, 3
Common mullein	*Verbascum thapsus*	1
Common tansy	*Tanacetum vulgare*	1
Dalmatian toadflax	*L. dalmatica*	1
Hound's tongue	*Cynogllossum officinale*	1
Meadow hawkweed[2]	*Hierarcium caespitoum*	1, 3
Orange hawkweed[2]	*Hieracium aurantiacum*	1, 2
Ox-eye daisy	*Chrysanthemum leucanthemum*	1, 2, 3
Perennial sow-thistle	*Sonchus arvensis*	1
Scentless chamomile	*Matricaria perforata*	1
Spotted knapweed[2]	*Centaurea maculosa*	1
Tall buttercup	*Rananculus acris*	1, 2, 3
Tall hawkweed	*Hieracium piloselloides*	1
White cockle	*Lychnis alba*	2
Wild caraway	*Carum carvi*	1, 2, 3
Yellow devil hawkweed	*Hieracium glomeratum*	1

[1] Corporate Region:
1. South Saskatchewan
2. North Saskatchewan
3. Upper Athabasca; only
These regions did surveys in 2014

[2] Prohibited noxious weeds



Wild caraway flower

Yellow devil hawkweed

Figure 15. Distribution of tall buttercup at selected survey sites in the Green Area in 2014.

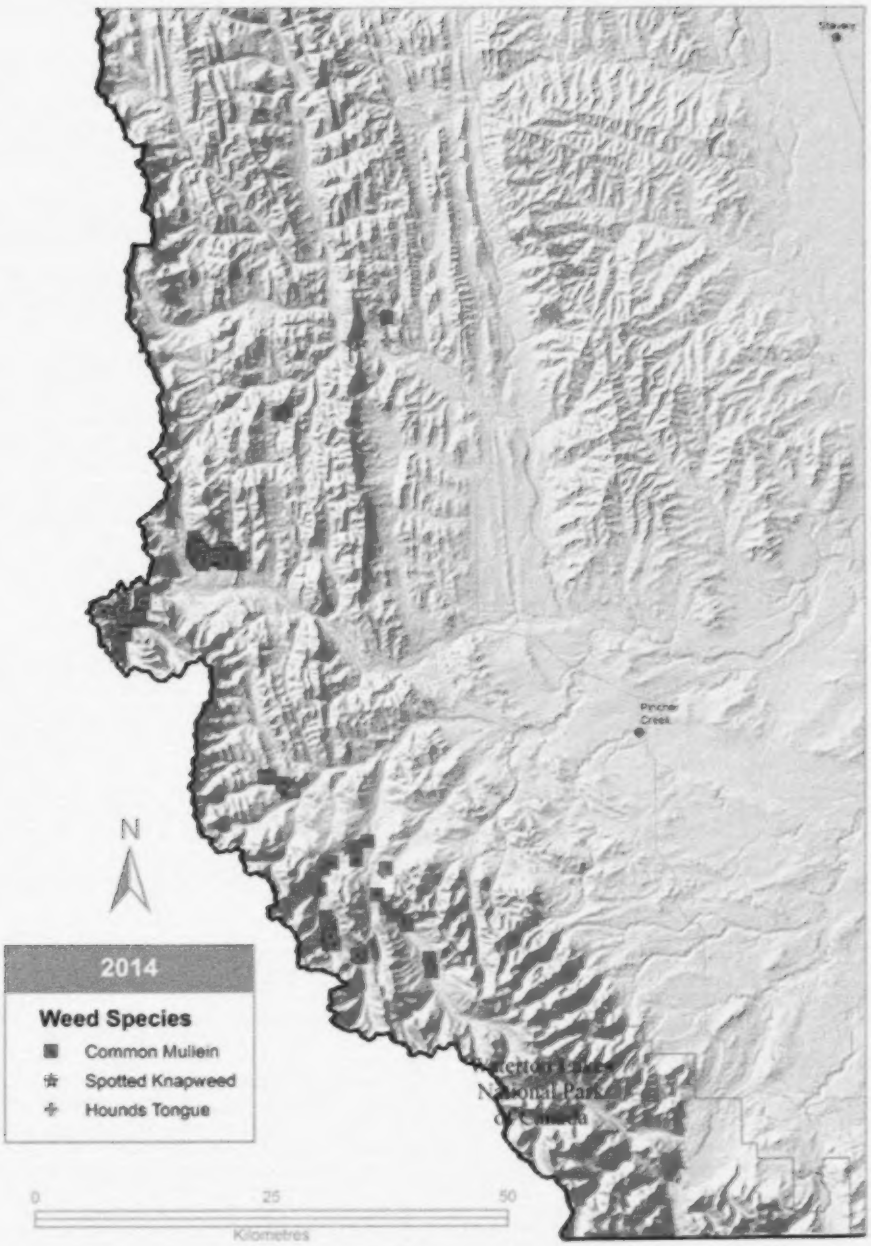


Figure 16. Distribution of invasive species of low prevalence at selected survey sites in the Green Area in 2014.

Figure 17. Distribution of wild caraway at selected survey sites in the Green Area in 2014.

Invasive Plant Management

In 2014, in the North Saskatchewan Region, ESRD facilities were treated for invasive plants in the Blackstone, Hummingbird, Onion Lake Trail, Cut Off and Eagle campgrounds, staging areas, and cabins. Fly-in weed control was completed in the Blackstone gap and in an outfitter camp along George Creek. The main camp west of Blackstone basin was heavily infested with tall buttercup. A horse camp on the trail to Job Lake was accessed and treated for the first time in 2014; it had a small dense patch of tall buttercup.

Orange hawkweed, a prohibited noxious invasive plant, was identified in both the North Saskatchewan Region and the Upper Athabasca Region. In the North Saskatchewan Region a pocket was found in 2013 at in the Medicine Lake area and treated with herbicide. In 2014 the patches were larger and herbicide was applied again. In the Upper Athabasca Region treatment is scheduled for 2015. In the Upper Athabasca Region near Hinton, hawkweed species continue to spread, making it harder each year to manage the infestations. Hawkweeds are listed as prohibited noxious weeds which require complete eradication. However, due to the high degree of infestation, this poses a challenge.

In 2014 the forest health program on invasive plant management in unoccupied areas of the South Saskatchewan Region Green Area included a contract to Spectrum Resources for survey and control on lands in the Municipality of the Crowsnest Pass and the Municipal District of Pincher Creek. An annual Memorandum of Understanding was renewed with the Municipal District of Ranchland to manage invasive plant infestations of common concern. Funds were also allocated to the Castle Crown Wilderness Coalition which targeted backcountry early detection, rapid response, and hand pulling in the Castle area.

The objective for the South Saskatchewan Region was to keep new species from establishing in uninfested areas. The first priority areas were the relatively weed-free south and west Castle valleys. All listed noxious and prohibited noxious weed species, and invasive yellow hawkweed species, were treated. The exception was tall buttercup, which is widespread in the area and not eradicable. The second priority was the Tent Mountain area. All listed noxious, prohibited noxious and invasive yellow hawkweed species were surveyed and controlled. The third priority was north of Highway 3, along the Atlas Road. Here, all listed noxious, prohibited noxious, invasive yellow hawkweed species and bull thistle were surveyed. Due to the many weed species and high densities in this area, only blueweed and bull thistle were controlled. These species were selected in an effort to prevent their establishment to the north in the Municipal District of Ranchland. Extensive survey and control work was completed along roads, trails and in cutblocks within the Municipal District. A fourth priority area was delineated in the Carbondale area but due to budget constraints, no contract work was conducted in this area.

More than 115 km of trails were surveyed and controlled by the contractor in the Municipalities of Crowsnest Pass and Pincher Creek. Of particular note was a previously unknown patch of spotted knapweed, a highly aggressive prohibited noxious weed that was discovered and treated. The Castle Crown Wilderness Coalition surveyed and/or controlled approximately 30 km of trails and roads. Of particular note was the discovery of the noxious weed field bindweed, which was previously unreported in this region. The field bindweed patch was treated with herbicide.

Invasive Plant Co-operatives

In the North Saskatchewan Region a co-operative program between ESRD and Sundre Forest Products was maintained in the Williams Creek area in 2014. Tall buttercup and wild caraway were the main targets, which have been successfully controlled by application of residual herbicides in 2013 and 2014.

Although it is beyond the regional boundary, Lower Athabasca Region Forest Health staff assessed the Amadou Co-operative Weed Management Area willow staking several times in 2014. The goal of willow staking is to advance ecological succession to control scentless chamomile. Weed plants were pulled and disposed of and growth of the willow stakes and poplar plugs were assessed. The area was relatively free of weeds and the growth of both the planted and volunteer native vegetation appeared healthy.

Biocontrol

The overall goal of biocontrol (or biological control) is to reduce the size and density of invasive plant infestations for which conventional methods of invasive plant control are not feasible due to size of infestation, difficult access, herbicide use restrictions, restrictions in riparian areas, no registered herbicide available for control, and cost. Biocontrol uses an integrated pest management approach to control a target species, in this case a weed, by taking advantage of its natural diseases or predators in order to control the invasive species.

Scentless chamomile has two agents available for release in Alberta: a gall-forming midge (*Rhopalomyia tripleurospermi*) and a seedhead-eating weevil (*Omphalapion hookeri*). In the Lower Athabasca Region weevils and midges were used as a biological control agents for scentless chamomile at a public gravel pit (an ESRD disposition) north of Wandering River and subsequently monitored by Forest Health staff. Galled plants colonized by midges were released in July 2013 and the weevils were released in August 2013. Monitoring in 2014 found no evidence the galled plants had survived, likely due to the hot dry August in 2013. However, the weevils had dispersed into the chamomile patch and appear to be successful. Two other sites on ESRD recreation dispositions were also identified as potential biological control locations for yellow toadflax.

One site west of Whitecourt in 2014 in the Upper Athabasca Region was treated with seedhead-eating weevils to control scentless chamomile. The release was made on a vacant Crown site adjacent to many re-generating cutblocks.

Hound's tongue has one approved biocontrol agent in Alberta: a stem-mining weevil (*Mogulones cruciger*). Releases of these agents were made in 2008 and again in 2009 in the south end of the Porcupine Hills. Monitoring of these releases in 2013 found the weevils still present and the plant population greatly reduced. *M. cruciger* is a very successful agent that will decimate a hound's tongue population before dispersing. Four more releases of this agent were made in 2014: two in the Castle and two more in the Porcupine Hills. These releases will be monitored annually and eventually the weevils will be collected for redistribution.

Over the years, there have been repeated attempts to establish a toadflax stem-mining weevil (*Mecinus janthinus*) in southern Alberta, but the warm temperatures associated with chinooks have caused premature insect emergence. Small populations have become established in central Alberta. In an attempt to mass rear these insects, common toadflax plants were collected from the Castle area near the Crowsnest Pass and insects collected (n=64) from established sites spent the summer on plants in a tent in Sundre. Female *M. janthinus* oviposit into the stems of toadflax and the larvae feed in the stems during development and then emerge as adults the next growing season. Stems infected with the weevils were cut, placed in the fridge, and the tent was dismantled on September 29th, 2013. Next season the emerging weevils will be released in the Castle area in a location that tends to hold a snowpack all winter. Once a population is established, agents from this 'nurse' site will be redistributed.

Collaborative Programs

Annual Gypsy Moth Detection Surveys

In 2014, Forest Health staff deployed 55 pheromone-baited Delta traps to detect gypsy moths over the Green Area as part of a province-wide annual survey coordinated by the Canadian Food Inspection Agency (CFIA). A gypsy moth trap at Gregoire Lake Provincal Park positively trapped a Gypsy Moth of the North American sub-species. This positive identification was done through DNA analysis in Ottawa by the CFIA.

As Gypsy Moth is an invasive species, its presence alone is a source of concern. No damage has been attributed to this agent in Alberta yet. However, due to its huge economic impacts in other parts of North America, the CFIA will be leading an intensive delimitation survey around the positive trap catch site with the help of Forest Health and Adaptation staff in 2015.

Gypsy Moth (North American sub-species) found in Gregoire Lake Provincal Park pheromone trap in 2014.

Monitoring of Climate Impacts on the Productivity and Health of Aspen (CIPHA)

The Forest Health and Adaptation program monitors CIPHA nodes in co-operation with The Canadian Forest Service, Northern Forestry Centre. Each node covers three aspen stands; each stand contains two monitoring plots. The CIPHA nodes are located in British Columbia, Alberta, Saskatchewan, Manitoba, Ontario and the Northwest Territories.

The intent of this collaboration is to monitor the nodes in Alberta, as part of a research project on interactions among climate, forest insects and diseases, and trembling aspen. Figure 18 indicates the locations of CIPHA nodes in Alberta.

In 2014, Forest Health and Adaptation staff monitored plots in seven out of the nine nodes in Alberta; two nodes were monitored by a team from the Northern Forestry Centre of the Canadian Forest Service. Forest Health and Adaptation staff annually record defoliation, dieback, foliage compliment, and signs and symptoms of pests. Data is submitted to the Canadian Forest Service for analysis. A summary of the analysis by Mike Michaelian with the Canadian Forest Service, Northern Forestry Centre is detailed on the next page.

Figure 18. Alberta CIPHA nodes.

"Despite an overall increase in aspen defoliation across the province in 2014, defoliation at the Alberta CIPHA sites remained relatively low with an average of 11 per cent. Defoliation at the Dunvegan CIPHA site decreased dramatically to approximately 17 per cent following two

years of almost complete defoliation (85 per cent). Defoliation did increase markedly at the Red Earth site, tripling to 28 per cent. Of the remaining sites, only Notikewin, Young's Point, and Edgerton showed a slight increase. Most of the defoliation was caused by forest tent caterpillar (*Malacosoma disstria*) which first appeared at CIPHA sites in 2011.

Phellinus tremulae, a decay fungus, which is twice as common in the parkland than in the boreal ecozone, has shown a slow but steady increase since the beginning of the CIPHA program in 2000. In 2014, almost 19 per cent of live aspen trees in the parkland were infected with *Phellinus*. The steady increase is largely expected since incidence of *Phellinus* is related to tree age.

Peniophora polygonia, another decay fungus, which is four times more common in the boreal than parkland ecozone, may actually be decreasing slightly in the boreal forest. In 2014, approximately 13 per cent of live aspen trees in the boreal ecozone were infected with *Peniophora*. The other fungal pathogens common to the CIPHA sites include the canker causing fungi *Cytospora chrysosperma* and *Entoleuca mammata*. Unlike *Phellinus* and *Peniophora*, these two fungi often cause tree death. Combined, these two fungi caused cankers on approximately 5 per cent of trees.

The combined incidence of the wood borers *Saperda calcarata*, *Agrilus liragus*, *Trypodendron retusum*, and *Dicerca* spp. was marginally higher in 2014 compared to 2013 with approximately 42 per cent of parkland and 23 per cent of boreal trees showing evidence of current or past borer activity. Although these numbers seem high, aspen can often survive borer attack, especially from *Saperda*, and damage caused by borers remains visible for many years. Surviving trees with signs of old borer activity are included in these incidence figures.

Moisture is crucial to aspen growth and the lack of moisture is a strong determinant of tree mortality. The parkland CIPHA sites, on average, showed a moderate increase in moisture in 2014 compared to 2013 as measured by the Climate Moisture Index (CMI). For the comparatively dry parkland, 2014 was one of only three in the last 15 years for which the CMI was above zero, zero being the point where precipitation equals potential evapotranspiration. The other positive years were 2005 and 2011. Water balance at the parkland sites in 2014 averaged 5 cm while moisture at the boreal sites remained flat compared to last year and averaged about 14 cm.

In 2014, the average annual rate of tree mortality increased from 3 to 5 per cent in both the parkland and boreal ecozones. This increase in mortality can be attributed largely to the increase in defoliation over the last number of years especially at a few CIPHA sites. Mortality at the Dunvegan site, for example, more than doubled to 20 per cent following two years of almost total defoliation. Mortality due to defoliation tends to be localized to specific CIPHA sites compared to mortality due to drought which is much more widespread, reflecting the scales of the underlying processes.

Excluding sites with high defoliation, the average annual rate of tree mortality increased slightly from just under 2 per cent in 2013 to 2.5 per cent in 2014 (Figure 19). This figure also shows that mortality, in the absence of defoliation, peaked in the mid to late 2000s and lagged behind the 2001-02 drought. The severity of this drought was unprecedented for at least the last 50 years. During the peak of mortality, biomass losses due to mortality were greater than the gains due to growth, leading to a net loss of biomass from aspen stands across western Canada. The slow return to rates of mortality within the historic average range implies that the effect of drought is likely to persist long after the drought event itself.

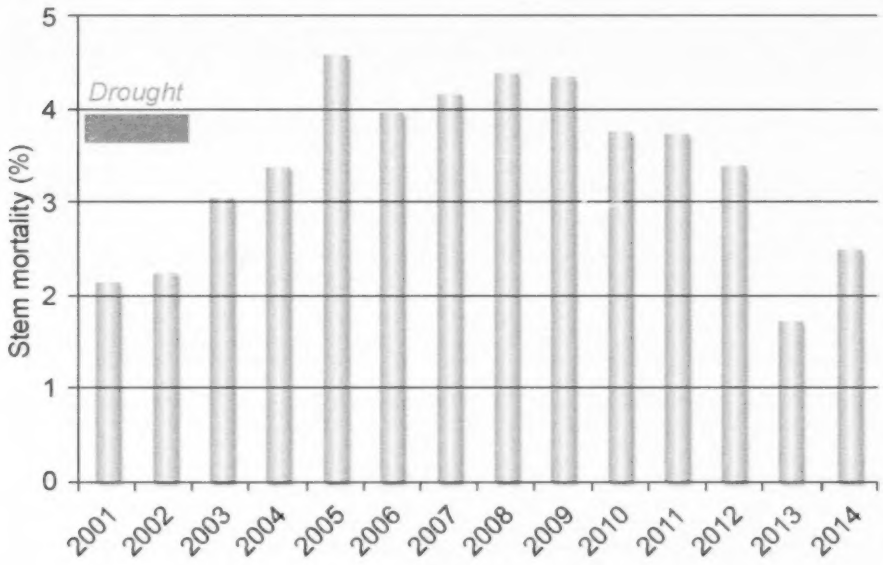


Figure 19. Average aspen mortality (newly dead stems as a percent of last year's living stems) for all CIPHA nodes across western Canada.

Most of the Alberta CIPHA sites followed this pattern of a decrease in mortality following a peak in the mid to late 2000s. The 2014 CIPHA assessments reveal that three sites will be of special interest in the next few years. The Notikewin site experienced a relatively strong drought for the last three years and mortality has just started to increase this year. We can expect an increase in mortality over the next few years. The second site of interest, Dunvegan, experienced high levels of forest tent caterpillar defoliation (~85 per cent) in both 2012 and 2013 but much lower defoliation in 2014 (~20 per cent). Mortality started to increase in 2012 and, as we predicted last year, it has dramatically increased in 2014. As with drought, defoliation leads to mortality that lags by a number of years. If defoliation remains low next year at the Dunvegan site, we will be provided with a good opportunity to determine just how persistent the effects of severe defoliation are. The third site of interest is Red Earth. It experienced a moderate level of defoliation in 2014 and mortality more than doubled over the previous year. If defoliation persists, mortality can be expected to increase even further.

Although there are many biotic and abiotic factors and interactions of factors affecting the health of aspen stands, the 2014 CIPHA results demonstrate the importance of both defoliation and drought on stand productivity and mortality. These two factors, more than any other factors, account for the majority of aspen mortality. Luckily Alberta, in recent history, has not experienced drought and defoliation concurrently or consecutively. In the future, Alberta's boreal forest is likely to experience simultaneous or near-simultaneous drought and defoliation, in which case we could expect much higher mortality and much lower growth."

Whitebark and Limber Pine

Both whitebark and limber pine are listed as endangered species in Alberta under the *Wildlife Act*. Whitebark pine is also listed as endangered federally under the *Species At Risk Act*. Both species grow very slowly, have marginal or no timber value, but extremely high value for wildlife, hydrology, slope stability, biodiversity, and aesthetics. They are keystone elements of their respective ecosystems, and losing these species would mean permanent changes to high elevation ecosystems they occupy, including loss of habitat for associated wildlife species. During the past century, these two species have undergone rapid range-wide declines, and are at risk of local extinction and reduction to as little as 1 to 5 per cent of their historic population sizes if key recovery actions are not taken.

Four causes of decline have been identified: 1) the alien invasive fungus causing white pine blister rust kills trees and seedlings, 2) mountain pine beetle targets cone bearing trees, 3) changes in wildfire regimes caused by both fire suppression and increased frequency and severity of fires kill trees and reduce habitat suitability for regeneration, and 4) climate change reduces suitable habitat and increases competition and mortality caused by shade tolerant species, insects and pathogens. Despite these challenges, experts have identified actions that can be taken that would successfully maintain and restore these species in their natural habitats.

Recovery plans for both species have now been completed with significant involvement by ESRD staff, as well as experts from provincial and federal parks agencies, Canadian Forest Service, and the Alberta Native Plant Council.

Alberta has made significant contributions to whitebark pine conservation and management through extensive seed collections. These are stored to preserve the embryos inside the seeds so they can be used as a genetic reservoir in the future. These seeds can also be used for studies on genetic diversity, seed germination, and restoration. Alberta has a network of forest health transects designed to monitor white pine blister rust, mountain pine beetle, and dynamics of limber and whitebark pine stands. This data is critical to assess the rate of decline and identify

priority stands for restoration and recovery activities. Methodology is standardized to allow comparisons for all high-elevation five-needle pines which are experiencing similar challenges throughout western North America.

The next steps for Alberta include: 1) training field crews to identify and document white pine blister rust, 2) selecting and monumenting candidate trees that may be resistant to blister rust, 3) protecting candidate trees from mountain pine beetle attack with Verbenone where warranted, and 4) developing and evaluating options for a rust resistance screening protocol to confirm whether apparently rust free trees actually have heritable disease resistance – if so, these trees will be a priority to protect and collect seed for future restoration projects.

Cooperative Action with the Terrestrial Environmental Effects Monitoring (TEEM) Program of Wood Buffalo Environmental Association

As part of an ongoing commitment, Forest Health and Adaptation staff performed Forest Condition surveys on approximately 40 pine sites for the Wood Buffalo Environmental Association's (WBEA) Terrestrial Environmental Effects Monitoring (TEEM) program. WBEA is a multi-stakeholder, not-for-profit organization that conducts air quality and terrestrial monitoring, largely in the Regional Municipality of Wood Buffalo. Their TEEM program monitors the effects of emissions from oil sands developments on natural ecosystems. Part of this includes forest health monitoring to establish "cause and effect" linkages, because a likely impact of pollutant air emissions is the predisposition of forest stands to various biotic, and abiotic, damaging agents (e.g., insects, disease, and drought).

In July, Forest Health staff from the Lower Athabasca and North Saskatchewan Regions and WBEA staff conducted assessments of the TEEM sites. These surveys consist of appraising tree condition criteria such as: cone production, crown condition (needle condition and retention), woody tissue damage, as well as insects and/or diseases in jack pine. This season, the ability to conduct forest condition surveys was greatly facilitated by improvements to landing sites made by Fort McMurray Wildfire Management Area personnel.

Invasive Alien Species Trapping Program

Starting in 2013, ESRD staff in the Lower Athabasca Region have assisted the Invasive Alien Trapping Program lead by the Society to Prevent Dutch Elm Disease (STOPDED). Pheromone traps are deployed near dumps or other facilities storing wood waste materials from industrial operations in northeast Alberta. In 2014, ESRD provided "in kind" support – setting up traps, collecting and submitting samples, and taking down traps at four sites. Of primary concern is detecting the presence of exotic wood boring beetles. In addition, pheromone traps for *sirex* wood wasps were also set and monitored at each site. To date there have been no invasive species identified in the trap catches. This project is an excellent example of collaboration, with partners including the STOPDED, municipal governments, the Canadian Food Inspection Agency, resource industry, and Olds College (where the samples are sent for analysis).

Increased Awareness and Training

Forest Health and Adaptation Newsletter

In 2014, the Forest Health and Adaptation program published three issues of the "Bugs and Diseases" newsletter. These three publications were expanded to include topics inclusive to Forest Health and Adaptation and their recent merger with the Alberta Tree Improvement and Seed Center.

Provincial Integrated Forest Pest Management Forum

The Integrated Forest Pest Management Forum was held on April 8, 2014. Due to the change in client needs, the forum format was altered. The new objective was to increase awareness across tree health professionals on current and potential forest and urban forest pest management issues in Alberta. The day consisted of a combination of speakers as well as booth sessions.

Speakers gave updates on current forest pest conditions for the Government of Alberta, City of Edmonton, the Society to Prevent Dutch Elm Disease (STOPDED), Canadian Food Inspection Agency, and the Canadian Forest Service. Other topics included insects and diseases on private lands, and climate change. The booth sessions allowed attendees to network and learn about the issues different groups face in regards to current and potential forest pest management. Attendees included individuals from municipalities, government agencies, and non-governmental agencies.

Workshop on the Identification and Management of Pests of Concern in Genetic Trials

On June 24, 2014 ESRD held a one day workshop on the identification and management of pests of concern in genetic trials. This workshop was part of the annual Forest Health and Adaptation professional development series. With the recent creation of the Forest Health and Adaptation Section, the purpose of this session was to further integrate the activities of Forest Health staff with those of the operations of the Alberta Tree Improvement and Seed Centre.

The workshop focused on foliar diseases and pests of seeds and cones in Alberta. The one-day workshop consisted of classroom instruction in the morning and an afternoon in the field assessing signs and symptoms.

Forest Health and Adaptation staff in ATISC clone bank for field pest identification course.

Seed Conservation Course

Forest Health and Adaptation held two sessions of a free two-day seed conservation course at ATISC. This year the participants included government forestry employees and commercial nursery representatives from both Alberta and British Columbia, oil industry reclamation coordinators and contractors, and academics from the University of Alberta and Northern Alberta Institute of Technology. It covered all orthodox seed and included sections on seed-air moisture relationships, seed and cone assessment, collection, post-harvest handling, seed longevity and storage, storage effects, germination, and dormancy.

North Eastern Weed Workshop

The annual North Eastern Weed Workshop was held May 29, 2014 in Athabasca with over 90 participants representing industry, contractors, various levels of government and other users. Credits were applied for and received through the relevant professional organizations.

Once again this workshop was successful in raising awareness of invasive plants and promoting cooperation among municipal and provincial governments, and industry.

Appendix 1

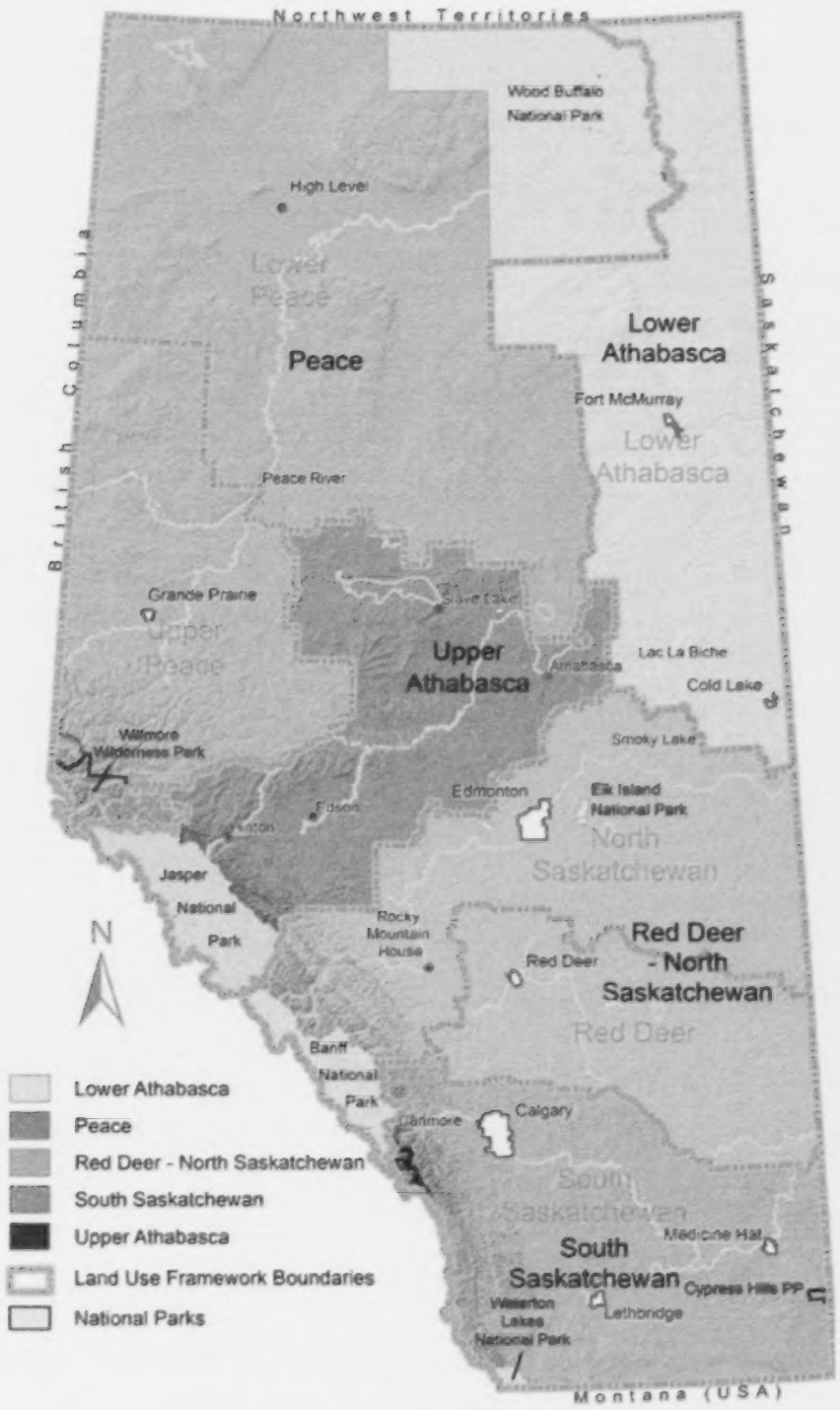


Figure 20. Map of ESRD Regions of Alberta, 2014.